Enceladus Scatterometry Rev 250

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- Sequence: s97
- Rev: 250
- Observation Id: en_250_1
- Target Body: Enceladus

1 Introduction

This memo describes one of the Cassini RADAR activities for the s97 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidelines for preparing the RADAR IEB. A 7-hour warmup occurs first using the parameters shown in table 4.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
250EN_WARMUP001_RIDER	2016-331T20:00:00	2016-332T03:00:00	07:00:0.0	
250EN_ENCEL001_PIE	2016-332T03:00:00	2016-332T05:00:00	02:00:0.0	SOST Rev250 PIE.

Table 1: en_250_1 CIMS Request Sequence

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	00:00:0.0	07:10:0.0	25.6	Warmup
b	distant_radiometer	07:10:0.0	00:09:0.0	0.5	Radiometer quick steps
c	distant_scatterometer	07:19:0.0	00:01:0.0	8.4	Scatterometer to force power on early
d	distant_scatterometer	07:20:0.0	00:29:30.0	12.4	Scatterometer rcv only off to on-target compressed 9 dB cal
e	distant_scatterometer	07:49:30.0	00:35:30.0	296.1	Scatterometer target-center (Enceladus) with tone
f	distant_scatterometer	08:25:0.0	00:10:0.0	4.2	Scatterometer rcv only on to off-target compressed 9 dB cal
g	distant_radiometer	08:35:0.0	00:05:0.0	0.3	Closing Radiometry
h	distant_radiometer	08:40:0.0	00:20:0.0	1.2	Closing Radiometry
Total				348.7	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	421246	off target	5.47	off target
b	191979	off target	2.49	off target
c	185223	off target	2.41	off target
d	184467	off target	2.40	off target
e	161628	161628	2.10	231
f	132872	132872	1.73	418
g	124543	off target	1.62	off target
h	120344	off target	1.56	off target

Table 3: Division geometry summary. Values are computed at the start of each division. B3 Doppler spread is for two-way 3-dB pattern. B3 size is the one-way 3-dB beamwidth

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	0.0	no	
end_time (min)	varies	430.0	no	
time_step (s)	varies	3600.0	no	Used by radiometer only modes - saves commands
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.992	yes	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: en_250_1 Div a distant_warmup block

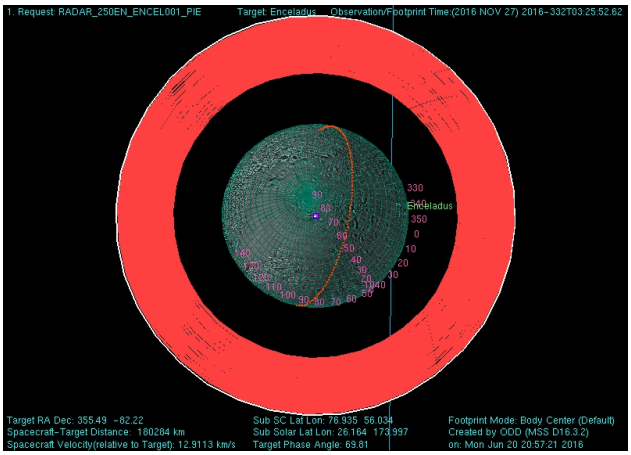

Figure 1: Div E: PDT view of Enceladus staring observation.

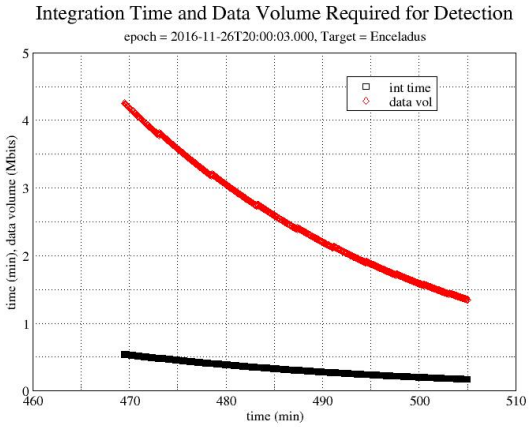

Figure 2: Scatterometry Div E: Detection integration time required for a single point detection using optimal chirp bandwidth

3 Overview

This observation is a distant scatterometry/radiometry observation of Enceladus. The observation begins with the usual radiometer only warmup. The radar collects compressed mode scatterometry for calibration use while turning on target. Both off-target and on-target data are acquired here. The main observation is a target centered stare with tone data.

4 Div E: Enceladus Distant Scatterometry

Figure 1 shows the pointing design for the scatterometry stare from the merged ckernel. The angular size of the target is about 2.7 mrad during this division. The beam 3 beamwidth is 6 mrad. The division parameters for the tone target integration are shown in table 5.

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	469.5	no	
end_time (min)	varies	505.0	no	
time_step (s)	don't care	8.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	no	
baq	5	5	no	
csr	0	0	no	0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration
noise_bit_setting	4.0	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.70	no	
prf (Hz)	varies	2000	no	Set to cover doppler spread
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	100	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	2	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	0.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	139.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 5: en_250_1 Div e distant_scatterometer block

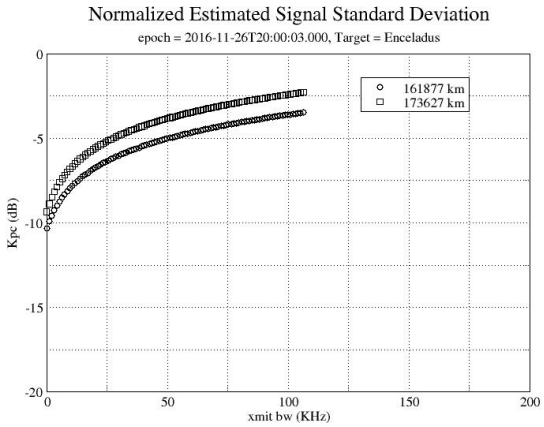

Figure 3: Div D: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

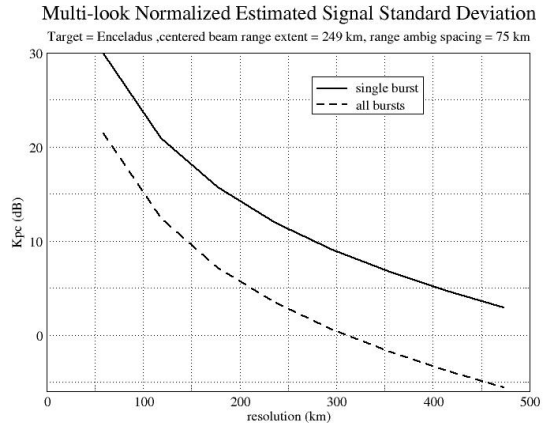

Figure 4: Div D: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown.

4.1 Distant Scatterometer Performance

The detection performance is shown in figures 2, 3, and 4. The maximum doppler spread in Div e is 418 Hz which comes from rotation and spacecraft motion. Figure 4 shows that range processing is marginal due to low SNR. The PRF is still set to 2000 Hz to cover the doppler spread and cleanly show the doppler spectrum. Disk integrated results from the tone division should be very stable.

5 Receive Only Calibration

Div's D and F collect compressed receive only data in the scatterometer mode with the 9 dB attenuator setting used by the target center observation. The data are obtained while turning between off- and on-target. These data along with knowledge of Enceladus's brightness temperature provided by the radiometry can then be processed into gain and noise temperature data for the instrument and later used to adjust calibration settings if needed. These data are collected in compressed mode to get more integration time. The PRF and number of pulses are chosen to fill the science data buffer. These parameters give the best performance possible from the compressed mode.

6 Revision History

1. Sep 20, 2017: Initial Release

7 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI